WATSON COLE STEVENS DAVIS, P.L.L.C.
Suite 1000
1400 K Street, N.W.
Washington, D.C. 20005-2477
(202) 628-0088

CASE DOCKET NO. JEL 30347
Date: April 1, 1997

COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, DC 20231

Sir:

Transmitted herewith for filing is a patent application:

INVENTORS: Masaharu MIYAHARA, Yasushi INOUE and Kenji SUGA

Serial No.: New Patent Application

Filed: April 1, 1997

For: HEAT SINK AND ELECTRONIC DEVICE EMPLOYING THE SAME

ENCLOSED ARE:

Specification pages 1-15, 9 Claims, Abstract, 4 sheets of drawings (Figs. 1-9), and an executed Declaration. Also enclosed are an Information Disclosure Statement with PTO-1449 and 1 JP reference with English Abstract, a Preliminary Amendment and an Assignment to MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.

THE FILING FEE HAS BEEN CALCULATED AS SHOWN BELOW:

BASIC FEE	$ 770.00
TOTAL CLAIMS: (9 - 20) = 0 (0 x $22.00)	+ 00.00
INDEPENDENT CLAIMS (6 - 3) = 0 (3 x $80.00)	+ 240.00
MULTIPLE DEPENDENT CLAIM PRESENTED ($260.00)	00.00
TOTAL OF ABOVE . . .	=$1010.00
LESS 50% REDUCTION FOR QUALIFIED SMALL ENTITY. .	-
TOTAL FILING FEE . .	=$1010.00
ASSIGNMENT RECORDATION FEE (+ $40.00) . .	+ 40.00
TOTAL ENCLOSED . .	=$1050.00

Check No. 23236 in the amount of $1050.00 to cover the filing fee and Assignment recordation fee is enclosed.

The Commissioner is hereby authorized to charge payment of the following fees associated with this communication and/or fees required during the pendency of this application (or credit overpayments) to DEPOSIT ACCOUNT No. 23-0576:

-/- Any additional filing fees or fees for presentation of extra claims under 37 CFR §1.16.
-/- Any patent application processing fees under 37 CFR §1.17.

Respectfully submitted,

James E. Ledbetter
Registration No. 28,732

Date: April 1, 1997
JEL/ndj

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Masaharu MIYAHARA, et al

Serial No.: New Patent Application

Filed: April 1, 1997

For: HEAT SINK AND ELECTRONIC DEVICE EMPLOYING THE SAME

PRELIMINARY AMENDMENT

Honorable Commissioner of
Patents and Trademarks
Washington, DC 20231

Sir:

Please amend the above application as follows:

IN THE CLAIMS

Please amend the claims as follows:

Claim 5, line 1, change "claim 3 or 4" to --claim 3--.

Claim 6, line 1, change "claim 4 or 5" to --claim 4--.

Claim 7, lines 1-2, change "claims 1 to 5" to --claim 1--.

Please add the following new claims:

--10. A heat sink according to claim 4, characterized in that the opening of the plate is so large as to allow the driving means to penetrate the plate but smaller in diameter than the fan.

11. A heat sink according to claim 5, characterized in that the heat sink further comprises a duct for directing air flow at least to one of the open side of the heat sink substrate and the open side of the cover.

12. A heat sink according to claim 2, characterized in that the fan has a shape of an axial fan.

13. A heat sink according to claim 3, characterized in that the fan has a shape of an axial fan.

14. A heat sink according to claim 4, characterized in that the fan has a shape of an axial fan.

15. A heat sink according to claim 5, characterized in that the fan has a shape of an axial fan.

16. A heat sink according to claim 10, characterized in that the fan has a shape of an axial fan.--

REMARKS

This Preliminary Amendment eliminates the multiple dependent claim status of claims 5-7 in order to avoid the multiple dependent claim surcharge.

Early and favorable consideration of this application is respectfully requested.

Respectfully submitted,

Date: April 1, 1997

James E. Ledbetter
Registration No. 28,732

JEL/ndj

Attorney Docket No. JEL 30347

WATSON COLE STEVENS DAVIS, P.L.L.C.
Suite 1000
1400 K Street, N.W.
Washington, D.C. 20005-2477
(202) 628-0088

E3206

23/9

HEAT SINK AND ELECTRONIC DEVICE EMPLOYING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a heat sink for cooling a semiconductor element which emits much heat such as a micro processing unit (referred to as an MPU hereinafter).

Description of the Prior Art

Heat sinks have been used for cooling semiconductors and the like which emit much heat. Recently, in particular, a fan-motor-integrated heat sink incorporated with a small fan is used for coping with the high heat emission of the MPU etc.

Conventional heat sinks will be described hereinafter. Fig. 8 is a perspective view of a conventional heat sink and Fig. 9 is a cross sectional view of the conventional heat sink.

In Figs. 8 and 9, reference numeral 81 denotes an MPU that is a high-exothermic semiconductor element, 82 a heat sink substrate which is mounted on the MPU 81, 83 radiator fins, 84 driving means such as a motor or the like, 85 a fan and 86 a structure such as the casing of a notebook-type personal computer etc. for defining a space above the heat sink.

The operation of a conventional fan-motor-integrated heat sink having the aforementioned structure will be described hereinafter. Heat emitted from the MPU 81 is transmitted to the heat sink substrate 82 and the radiator fins 83. Air flow generated by the fan 85 rotated by the driving means 84 is taken in between the structure and the upper surface of the heat sink as shown by an arrow A and passes among the radiator fins 83 while carrying off heat therefrom to be vented from the side surface thereof as shown by an arrow B.

The aforementioned conventional structure had a problem that it was impossible for thin devices such as the notebook-type personal computer limited in thickness to secure a sufficient space for taking in air above the heat sink from above the heat sink and consequently to secure a sufficient cooling performance. Although the entire heat sink may be made thin for securing the space, a motor capable of rotating the fan to generate a sufficient amount of air flow for cooling the device required a certain degree of thickness because of the structure of its bearing and coil, so that the motor was structurally limited in being made thin.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a fan-motor-integrated heat sink capable of effectively supplying cooling air flow to an element

even if the same is a heat emitting element such as an MPU etc. employed by a thin device which cannot secure a sufficient space above the heat sink.

In order to attain the above object, the present invention obtains a sufficient space for taking in air between the upper surface of the heat sink and the casing of a device by making the height of the fan and those of the fins of the heat sink lower than the height of the upper surface of driving means such as a motor which is structurally limited in thickness relative to the heat sink substrate. Furthermore, the heat sink substrate and the fins are formed such that air is vented only in one direction to compensate for the reduction of cooling performance caused by the miniaturizing the fan and the fins of the heat sink substrate, and a cover is provided on the inlet side to prevent the vented air from being taken in.

This structure enables arranging a structure above the heat sink nearly as low as the height of the motor and consequently mounting the heat sink on a thin device.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a heat sink according to a first embodiment of the present invention;

Fig. 2 is a plan view of the heat sink according to the first embodiment of the present invention shown in Fig. 1;

Fig. 3 is a cross-sectional view of the heat sink according to the first embodiment of the present invention;

Fig. 4 is a perspective view of a heat sink according to a second embodiment of the present invention;

Fig. 5 is a cross-sectional view of the heat sink according to the second embodiment of the present invention;

Fig. 6 is a perspective view of a heat sink according to a third embodiment of the present invention;

Fig. 7 is a view showing the inside of an electronic device which incorporates therein the heat sink according to the third embodiment of the present invention;

Fig. 8 is a perspective view of a conventional heat sink; and

Fig. 9 is a cross-sectional view of the conventional heat sink.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described hereinafter with reference to Figs. 1 to 7.

Fig. 1 is a perspective view of a heat sink according to a first embodiment of the present invention, Fig. 2 is a plan view of the heat sink according to the first embodiment of the present invention, and Fig. 3 is a cross-sectional view of the heat sink according to the first embodiment of the present invention.

In Figs. 1, 2 and 3, reference numeral 1 designates a heat emitting element such as an MPU or the like on which a heat sink is mounted for cooling, the heat emitting element 1 having, for example, in case of an MPU, usually a shape of a quadrangle such as a square, a rectangle or the like having a side of 40 mm to 50 mm. Numeral 2 is a heat sink substrate, which is substantially square-shaped in outline almost similar to the heat emitting element 1 and which may be made of resin such as plastics without being limited to metals such as aluminum, brass, etc. so long as it is high in thermal conductivity as a member. The heat sink substrate 2 may be in outline of other shapes such as a circle as needed. The heat sink substrate 2 having a flat edge surface is mounted on the heat emitting element 1 according to a fixing method, using a bond, hooks, screws, etc. such that the flat side thereof is in contact with the upper surface of the heat emitting element 1. A side wall 3 is provided on three other edge surfaces of the heat sink substrate 2, the side wall 3 being provided along the edge surfaces of the

heat sink substrate 2 at the outer side thereof and being substantially circular around the rotating axis of a fan 7, described later, at the inner side thereof. The side wall 3 defines the direction of air flow and the blowing-out direction thereof and serves as a fin as well. An edge of the heat sink substrate 2 where no side wall 3 is provided becomes an outlet 4. Numeral 5 designates a plurality of radiator fins, which are provided substantially in parallel to the flowing out direction of air in the vicinities of the outlet 4 while substantially in circular arcs each having a predetermined length with its center at the rotating axis of the fan 7, described later, in other places. Although they are arranged substantially in circular arcs according to this embodiment, they may be arranged substantially along a spiral. Numeral 6 is a motor serving as driving means, which motor 6 is fixed to the surface of the heat sink substrate 2 on which the radiator fins 5 are provided according to a fixing method using a bond, screws, press fitting, etc. Numeral 7 designates an axial fan rotated by the motor 6, which fan 7 is arranged inside the side wall 3 for generating air flow to take in and blow out air. The fan 7 is made of metal having high thermal conductivity such as aluminum etc. for enhancing radiator effect. Incidentally, it may be made of resin such as plastics etc., not being limited to metal so long as it is high in thermal conductivity as a member. Numeral 8 is a

cover for covering the edges of the heat sink substrate 2 where the side wall 3 is provided, which cover 8 has an opening larger in diameter than the outer diameter of the motor 6 and smaller than the outer diameter of the fan 7 and which is mounted on the side wall 3 of the heat sink substrate 2 using a bond, screws, pressure welding etc. Numeral 9 designates a structure such as the casing of a notebook-type personal computer for regulating space above the heat sink.

The side wall 3 is smaller in height than the motor 6. The fan 7 is provided on the side surface of the motor 6 being shifted toward the lower end thereof, such that the upper surface of the fan 7 is lower than the upper surface of the motor 6, being in height between the heat sink substrate 2 and the cover 8. The fins 5 are so high as not to touch the fan 7 thereunder while substantially as high as the side wall 3 in the vicinity of the outlet 4 and outside the fan 7. As shown in Fig. 3, even if the structure 9 is designed to be arranged close to the upper surface of the motor 6, there exists a sufficient space into which air flows between the structure 9 and the cover 8, so that it is possible to generate a smooth air flow by the rotation of the fan 7.

The operation of the heat sink having the above structure will be described with reference to drawings.

In Fig. 3, heat generated in the heat emitting element 1 is transmitted to the heat sink substrate 2, the side wall 3, the radiator fins 5 and the cover 8. Air flow generated by the fan 7 rotated by the motor 6 is taken in from above the heat sink as shown by an arrow A, passes through the opening of the cover 8 and among the fins 5 while carrying off heat therefrom toward the outlet 4 and is vented from the side surface of the heat sink as shown by an arrow B. Even in case that the upper structure 9 is arranged as close as possible to the upper surface of the motor 6 in order to make the device thin, the structure of the present invention can secure an inflow route of air since it can afford a space above the cover 8. A conventional structure employing a motor having the same thickness cannot secure the amount of air flow since the inflow route is blocked although the fan is exposed to the outside more largely than the structure of the present invention. In addition, in case that the motor itself is made thin in the conventional structure, the inflow route of air can be secured but the reduction of motor output cannot be avoided, so that the amount of air flow is reduced. Thus with the structure of the present invention, an effective cooling becomes possible since the inflow route of air is secured without reducing the motor output.

Next, the operation of the cover 8 will be described with reference to Fig. 3 as well. In a heat

sink having the above structure, the fan 7 can have either of the structure of an axial fan or that of a centrifugal fan. However, since the advantage of the heat sink according to the present invention resides in being able to be made thin and it is mainly used for cooling the semiconductor elements in a thin electronic device, the outer dimension of the heat sink is about 40mm in side length and about 10mm in height. Therefore, the dimension of the fan in height needs to be limited to about 5mm in order to secure a sufficient route for air flow between the upper surface of the heat sink and the structure 9. In addition, the length of a fan blade needs to be limited to about 30mm. Although a conventional heat sink as shown in Fig. 9 usually employs a centrifugal fan such as a scirocco fan for taking in air from above and venting it in a side direction, the present invention employs an axial fan since a sufficient blade length cannot be obtained for the centrifugal fan. Without the cover 8, air flow directed downward by the fan 7 is reversed in flowing direction by the heat sink substrate 2 to escape toward the inlet through spaces among the blades of the fan 7 or through space between the fan 7 and the inner wall of the heat sink substrate 2. Providing the cover 8 to cover a part of the fan 7 is effective for restraining the escape. In case that the diameter of the opening of the cover 8 is larger than the envelope of the tip ends of the fan 7, the escape toward the inlet occurs much.

Alternatively, in case that the diameter of the opening of the cover 8 is too smaller than the envelope of the tip ends of the fan 7, the small area of the inlet opening reduces the amount of inflow air. In practical use, since the performance varies depending on the structure inside the device such as the structure 9, the opening dimension is set to be optimal to the device.

Incidentally, although the motor 6 is mounted on the heat sink substrate 2 according to this embodiment, it may be mounted on the cover 8 so as to be mounted on the heat sink substrate 2 by way of the cover 8.

A second embodiment will now be described. Fig. 4 is a perspective view of a heat sink according to the second embodiment of the present invention, and Fig. 5 is a cross-sectional view of the heat sink according to the second embodiment of the present invention.

Reference numeral 11 designates a heat emitting element such as an MPU etc. on which the heat sink is mounted for cooling, 12 is a heat sink substrate, 13 designates a side wall provided on three edge surfaces of the heat sink substrate 12, 14 designates an outlet for blowing out air formed on an edge surface of the heat sink substrate 12 where no side wall 13 is provided, 15 designates a plurality of radiator fins integrally provided with the heat sink substrate 12, 16 is a motor serving as driving means, 17 is an axial fan rotated by the motor 16, 18 is a first

cover for covering the edges of the heat sink substrate 12 where the side wall 13 is provided, and 21 designates a structure such as the casing of a notebook-type personal computer for regulating a space above the heat sink. The components described above are similar to those according to the first embodiment, so that the description thereof is omitted. Numeral 19 is a second cover which is substantially quadrangular and concave in outline and one side of which is open with an inlet 20 for determining the inflow direction of air. The second cover 19 is mounted on the heat sink substrate 12 such that the inlet 20 is directed in a predetermined direction relative to the heat sink substrate 12.

The operation of the heat sink having the above structure according to the second embodiment will be described with reference to Figs. 4 and 5. The heat sink substrate 12, the outlet 14, the fins 15, the motor 16, the fan 17 and the first cover 18 have the same structures as those of the first embodiment set forth above, and the second cover 19 is mounted thereon. The second cover 19 has the inlet 20 at one edge surface thereof, from which air is taken in by the rotation of the fan 17 and is blown out from the outlet 14 while passing among the fins 15 to carry off heat therefrom. The second cover 19 can be mounted on the heat sink substrate 12 such that the inlet 20 is directed in a predetermined direction, thereby realizing a heat sink which takes in air from a predetermined direction and

vents the air in a predetermined direction. Thus, in case that it is necessary to cool parts emitting large amount of heat inside a device equipped with the heat sink, it is possible to take in air from an optimal direction, thereby enabling the optimization of the effect of cooling the entire casing containing an MPU and the like. In addition, the structure 21 provided in the casing of a notebook-type personal computer etc. for regulating a space above the heat sink can sufficiently secure the inflow route of air even if it is in contact with the upper surface of the second cover 19, thereby eliminating the variation of performance due to the space between the heat sink and the structure 21 to facilitate designing the device.

It is possible to mount the second cover 19 on the heat sink substrate and take in air from a direction also in the conventional structure, but the thickness of the heat sink substrate increases by that of the second cover 19. In case that the second cover 19 is mounted on the heat sink according to the second embodiment of the present invention, it is possible to arrange the motor 16 and the second cover 19 closely to each other, thereby realizing a thin heat sink capable of taking in air from a direction and venting the air in one direction. Devices requiring the one-direction air taking and the one-direction air venting are mainly thin devices limited in space, so that the thin one-direction air taking and one-direction air venting heat sink

having the structure of the present invention can realize a large effect.

Then, a third embodiment will be described. Fig. 6 is a perspective view of a heat sink according to the third embodiment of the present invention, and Fig. 7 is a view showing the inside of an electronic device in which a heat sink according to the third embodiment of the present invention is incorporated.

Reference numeral 60 designates a heat emitting element, 61 is a heat sink similar to that of the second embodiment, 62 is an inlet provided in the heat sink 61 for taking in air, 63 designates an outlet provided in the heat sink 61 for venting air therefrom, 64 is a first duct connected to the inlet 62, and 65 is a second duct connected to the outlet 63. Although the figure illustrates the first duct 64 and the second duct 65 each having a rectangular cross section similar to that of the inlet 62 or that of the outlet 63, they can have any shape, for example, it is also possible that the tip end of the first duct 64 at the side of taking in air has a shape laterally wider than the inlet 62 and the tip end of the second duct 65 at the side of venting air has a shape of a circle or the like larger than the outlet 63. Alternatively, the duct can be provided only at either of the inlet 62 or the outlet 63. In Fig. 7, reference numeral 70 designates the casing of an electronic device, 71 is a printed board on which electronic parts, heat emitting elements etc. are

arranged to constitute an electric circuit, and 72 is a heat emitting device such as a power supply. The first duct 64 at the side of the inlet 62 has its opening in the vicinity of the heat emitting element 72 such as the power supply inside the electronic device, while the second duct 65 at the side of the outlet 63 has its opening at the exhaust port of the casing 70 of the electronic device. Air flow generated by the heat sink 61 takes in air around the heat emitting element 72 through the first duct 64, passes through the heat sink 61 and is vented from the casing of the electronic device through the second duct 65.

The operation of the heat sink having the above structure according to the third embodiment will be described with reference to Figs. 6 and 7.

As shown in Fig. 7, providing the first duct 64 and the second duct 65 in the heat sink enables taking in air at a predetermined position from a predetermined direction and venting the air to a predetermined position in a predetermined direction, thereby eliminating the restriction in the direction and position in taking in and venting air caused by the position of the MPU or that of the printed board. Without the first duct 64 at the inlet side, the heat sink 61 only takes in air on the printed board 71, but providing the opening of the first duct 64 in the vicinity of a specific component, for example, the power supply 72, enables taking air as well as cooling the

power supply 72. In addition, providing the opening of the second duct 65 at the exhaust port of the casing 70 enables discharging the heat of the heat emitting element 60 or that of the power supply 72 from the casing with certainty, thereby preventing the heat from diffusing therein. It is also possible to eliminate the necessity of additionally providing a fan for exhausting air other than the heat sink in the casing, thereby simplifying the structure.

The present invention can be embodied in other various forms without departing from the spirit or main features thereof. Therefore, the preferred embodiments set forth above are illustrated only by way of examples in all respects, and should not be interpreted by way of limitation. The scope of the present invention is represented by the scope of claims for a patent but not restrained by the specification at all. Furthermore, the modifications or variations belonging to the equivalent of the scope of claims for a patent are all within the scope of the present invention.

WHAT IS CLAIMED IS:

1. A heat sink comprising:

a heat sink substrate having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate; and

a fan rotated by said driving means;

characterized in that

height of an upper surface of said side wall is lower than that of an upper surface of said driving means relative to a bottom of said heat sink substrate.

2. A heat sink comprising:

a heat sink substrate having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate;

a fan rotated by said driving means; and

a concave cover which is mounted on an upper surface of the side wall of said heat sink substrate and which has a side wall except at one side thereof, the side being left open in one direction;

characterized in that

height of an upper surface of said side wall is lower than that of an upper surface of said driving means relative to a bottom of said heat sink substrate; and

the open side of said heat sink substrate is differently directed from the open side of said cover with respect to an rotating axis of said fan.

3. A heat sink comprising:

a heat sink substrate having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate;

a fan rotated by said driving means; and

a plate which is mounted on upper surface of the side wall of said heat sink substrate and which has an opening;

characterized in that

height of an upper surface of said side wall is lower than that of an upper surface of said driving means relative to a bottom of said heat sink substrate.

4. A heat sink comprising:

a heat sink substrate having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate;

a fan rotated by said driving means;

a plate which is mounted on an upper surface of the side wall of said heat sink substrate and which has an opening; and

a concave cover which is mounted on an upper surface of the side wall of said heat sink substrate and which has a side wall except at one side thereof, the side being open in one direction;

characterized in that

height of an upper surface of said side wall is lower than height of an upper surface of said driving means relative to a bottom of said heat sink substrate and the open side of said heat sink substrate is differently directed from the open side of said cover with respect to a rotating axis of said fan.

5. A heat sink according to claim 3 or 4, characterized in that the opening of the plate is so large as to allow the driving means to penetrate the plate but smaller in diameter than the fan.

6. A heat sink according to claim 4 or 5, characterized in that the heat sink further comprises a duct for directing air flow at least to one of the open side of the heat sink substrate and the open side of the cover.

7. A heat sink according to any one of claims 1 to 5, characterized in that the fan has a shape of an axial fan.

8. An electronic device comprising:

a substrate having a heat emitting element thereon;

a heat sink substrate mounted on said heat emitting element and having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate;

a fan rotated by said driving means;

a plate which is mounted on an upper surface of the side wall of said heat sink substrate and which has an opening; and

a concave cover which is mounted on an upper surface of the side wall of said heat sink substrate and which has a side wall except at one side thereof, the side being left open in one direction;

characterized in that

height of an upper surface of said side wall is lower than that of an upper surface of said driving means relative to a bottom of said heat sink substrate and said heat sink substrate is mounted on said cover for cooling the heat emitting element with their open

sides directed in different directions with respect to a rotating axis of said fan.

9. An electronic device comprising:

a casing having an exhaust port;

a substrate which is accommodated in said casing and has a heat emitting element;

a heat sink substrate mounted on said heat emitting element and having a vertical side wall except at one side thereof, the side being left open in one direction;

a plurality of fins vertically projecting from said heat sink substrate;

driving means at least a part of which is fixed to said heat sink substrate;

a fan rotated by said driving means;

a plate which is mounted on an upper surface of the side wall of said heat sink substrate and which has an opening; and

a concave cover which is mounted on an upper surface of the side wall of said heat sink substrate and which has a side wall except at one side thereof, the side being left open in one direction;

characterized in that

height of an upper surface of said side wall is lower than that of an upper surface of said driving means relative to a bottom of said heat sink substrate and said heat sink further comprises a duct for connecting the exhaust port of said casing and the open

side of said heat sink substrate or the open side of said cover.

ABSTRACT OF THE DISCLOSURE

The present invention aims to provide a fan-motor-incorporated heat sink capable of effectively supplying air flow for cooling even if there is no sufficient space above the heat sink as the result of thinning an electronic device.

In order to attain the object, a heat sink according to the present invention obtains a sufficient space for taking in air above the heat sink by making a fan, the fins of a heat sink substrate and the side wall thereof lower than driving means such as a motor and the like which are structurally restricted in thickness. In addition, the heat sink substrate and the fins are formed such that air is exhausted only in one direction and a cover is provided on the side of the heat sink substrate on which a motor is mounted and to which air is taken in to prevent exhausted air from being taken in.

With this arrangement, it is possible to arrange the structure of the electronic device close to the upper surface of the motor on the heat sink, thereby facilitating the installation of the heat sink on a thinned electronic device and improving the effect of cooling a heat emitting element.

APPLICATION FOR UNITED STATES PATENT E3206-01 (-K)

Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

1 the invention entitled: "HEAT SINK AND ELECTRONIC DEVICE EMPLOYING THE SAME"

the specification of which 2 (file no. _____)

(check at least one)

3 ☒ is attached hereto

4 ☐ was filed on _____ as (5) U.S. Application Serial No. _____

6 ☐ and was amended on _____ (if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.

7 ☐ was filed as PCT international application

8 Number _____

9 on _____

and was amended under PCT Article(s) 19 and/or 34

10 on _____ (if applicable).

11 priority date claimed in PCT International Application

_____ (Country) _____ (Number) _____ (Day/Month/Year Filed)

I hereby declare that I have reviewed and understand the contents of the above identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed:

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119

				Priority Claimed	
12a	Japan (Country)	08-082306 (Number)	4 April, 1996 (Day/Month/Year Filed)	☒ Yes	☐ No
	_____ (Country)	_____ (Number)	_____ (Day/Month/Year Filed)	☐ Yes	☐ No

Priority Claim(s) from U.S. Provisional Application(s) - I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

12b

Application No.	Day/Month/Year Filed	Application No.	Day/Month/Year Filed

Do not use this portion to identify a PCT application if the present application is the U.S. National phase of that PCT application

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.

13

(U.S. Application Number)	(U.S. Filing Date)	Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Watson Cole Stevens Davis, P.L.L.C. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

Robert J. Lasker, Reg. No. 22785; Richard C. Harris, Reg. No. 17194; Lawrence R. Radanovic, Reg. No. 23077; William A. Knoeller, Reg. No. 20929; Richard H. Tushin, Reg. No. 27297; James E. Ledbetter, Reg. No. 28732; Donald N. Huff, Reg. No. 27561; Thomas P. Pavelko, Reg. No. 31689; John P. DeLuca, Reg. No. 25505; James A. Poulos, III, Reg. No. 31714; Anthony P. Venturino, Reg. No. 31674; Walter D. Ames, Reg. No. 17913; and Ellsworth H. Mosher, Reg. No. 14717.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO WATSON COLE STEVENS DAVIS, P.L.L.C. 1400 K Street, N.W., Suite 1000, Washington, D.C. 20005-2477, TELEPHONE (202) 628-0088, FACSIMILE (202) 628-8034.

See page 2 for signature lines

See other side for instructions for completing this form

3206-01 (X)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

*14a Typewritten Full Name of Sole or First Inventor: Masaharu MIYAHARA (Given Name / ~~Middle Name~~ / Family Name)

*15a Inventor's Signature: ☞ Masaharu Miyahara

*16a Date of Signature: ☞ March 21, 1997 (Month / Day / Year)

17a Residence: Nakatsu-shi, Japan (City / State or Province / Country)

18a Citizenship: Japan

19a Post Office Address (*Insert complete mailing address, including country*): 2-13, Chuomachi-2-chome, Nakatsu-shi, Japan.

*14b Typewritten Full Name of 2nd Inventor *(if any)*: Yasushi INOUE (Given Name / ~~Middle Name~~ / Family Name)

*15b Inventor's Signature: ☞ YASUSHI INOUE

*16b Date of Signature: ☞ March 21, 1997 (Month / Day / Year)

17b Residence: Usa-shi, Japan (City / State or Province / Country)

18b Citizenship: Japan

19b Post Office Address (*Insert complete mailing address, including country*): 1533-1-1107, Yokkaichi, Usa-shi, Japan.

*14c Typewritten Full Name of 3rd Inventor *(if any)*: Kenji SUGA (Given Name / ~~Middle Name~~ / Family Name)

*15c Inventor's Signature: ☞ Kenji Suga

*16c Date of Signature: ☞ March 21, 1997 (Month / Day / Year)

17c Residence: Nakatsu-shi, Japan (City / State or Province / Country)

18c Citizenship: Japan

19c Post Office Address (*Insert complete mailing address, including country*): 8-42, Chuomachi-1-chome, Nakatsu-shi, Japan.

*14d Typewritten Full Name of 4th Inventor *(if any)*: (Given Name / Middle Name / Family Name)

*15d Inventor's Signature: ☞

*16d Date of Signature: ☞ (Month / Day / Year)

17d Residence: (City / State or Province / Country)

18d Citizenship:

19d Post Office Address (*Insert complete mailing address, including country*):

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than three inventors, please add a copy of this page for identification and signatures for the additional inventors.

FIG. 1

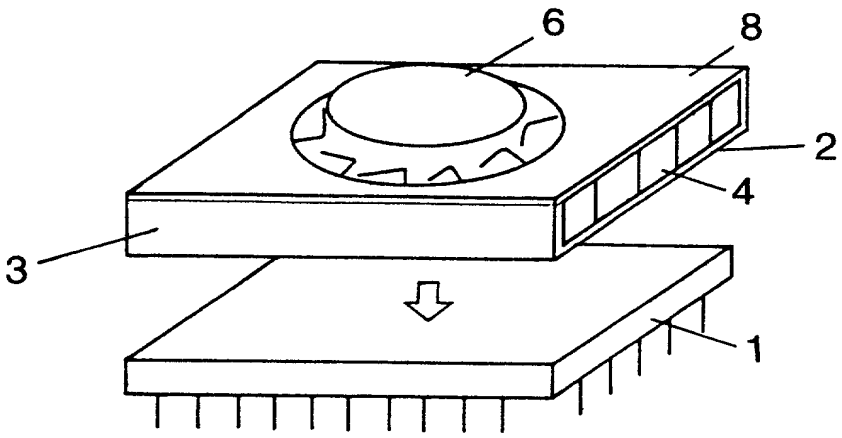

FIG. 2

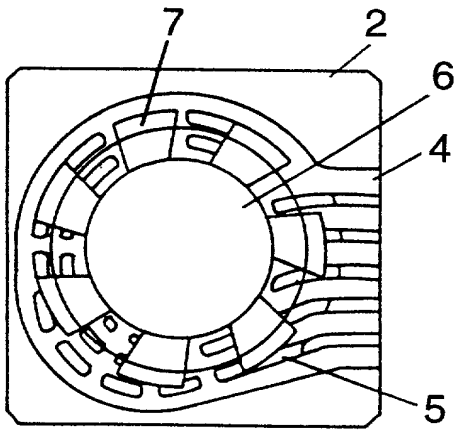

FIG. 3

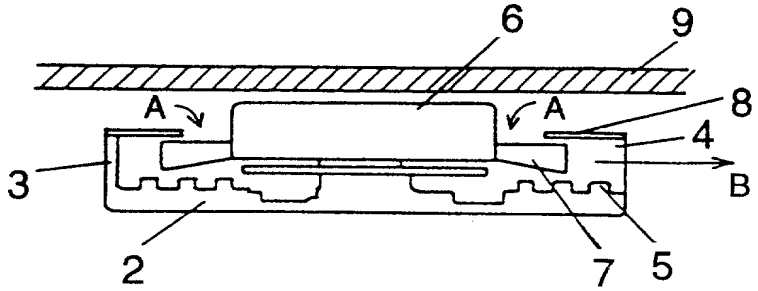

FIG. 4

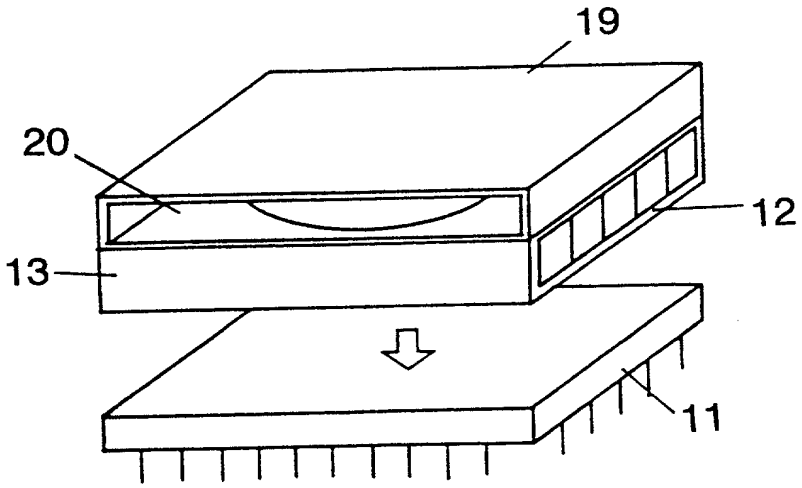

FIG. 5

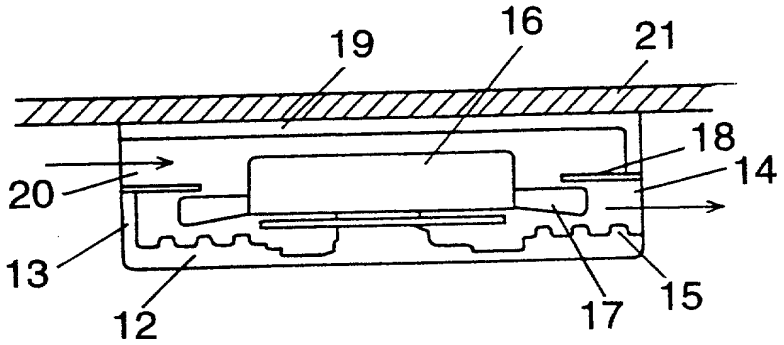

FIG. 6

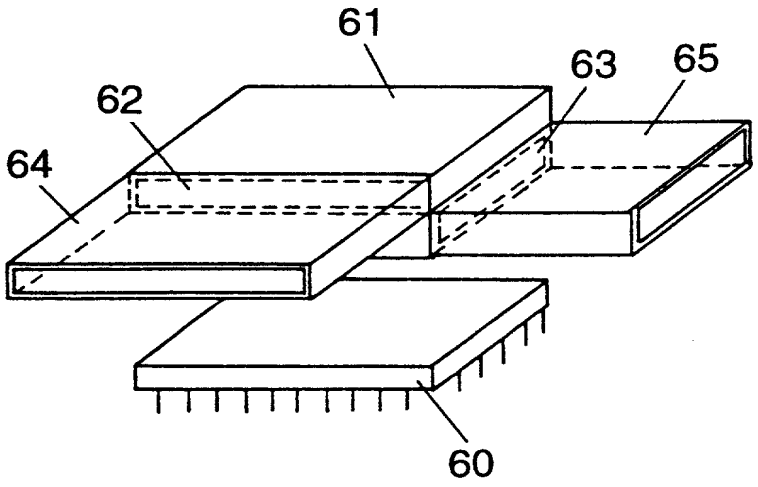

FIG. 7

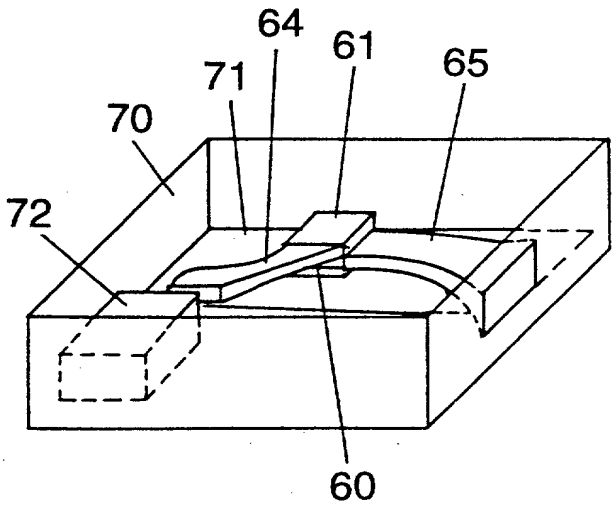

FIG. 8

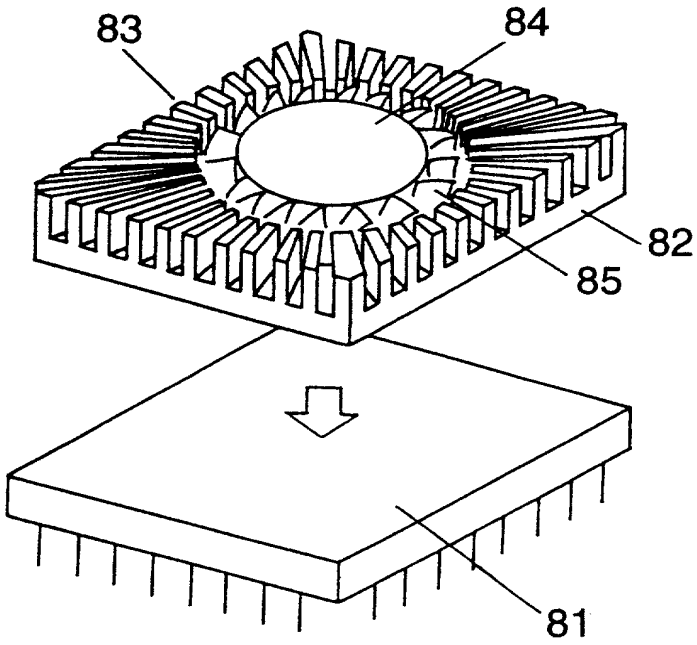

FIG. 9